

THE GENUS *GABRIELONA* (PHASIANELLIDAE) IN THE INDO-PACIFIC AND WEST INDIES

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This is the first part to be published of a monograph on the systematics of all the Indo-Pacific Phasianellidae. The other parts will comprise a general introduction, methods, a bibliography, index, and treatments of the genera *Phasianella* and *Tricolia* (including the subgenus *Hiloa* Pilsbry). Conventional approaches to the systematics of these groups, i.e. studies of shells and radulae, have yielded inconclusive results on how species should be categorized, and further biological studies are planned on them. The data on *Gabrielona* systematics are published in the meantime because they involve fewer unresolved problems and because there are new taxa (*G. pisinna*,

G. raunana goubini and *G. sulcifera*). Biological data relevant to systematics are unlikely to be obtained for this rarely collected genus.

Small, low-spired *Tricolia* specimens, which are far more common than *Gabrielona*, have been mistaken for *Gabrielona*. The generic characters detailed in this paper should help to dispel such misidentifications in the future. *Gabrielona* is distantly related to the other two genera grouped in the Phasianellidae.

Genus *Gabrielona* Iredale, 1917

Type-species: Phasianella nepeanensis
Gathiff and Gabriel, 1908

Chief distinguishing characters—The shells are small (*G. hadra*, the largest known species, can be 3.3 mm. long), with globose outlines and low

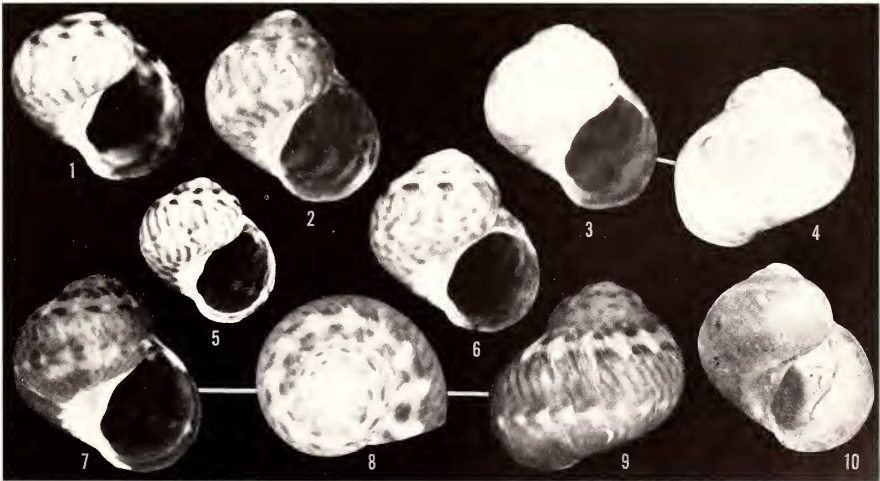


Plate 36 *Gabrielona nepeanensis* (Gathiff and Gabriel). Figs. 1-2, 5, 7-9. South Australia. Figs. 3-4, 6, 10. Victoria, Australia.

Fig. 10. Holotype. Fig. 1, $\times 30$; Figs. 2-10, $\times 20$.

spires. Sculpture, if present, is most prominent on the early whorls. Colors are pinks, reds, or browns, and white. Inside the aperture there is a spiral palatal sulcus which, if high in the aperture, is positioned beneath a spiral, subsutural feature of the color pattern on the external surface. All the species but *G. raunana* have from one to three apertural denticles. All the species are umbilicate, with an umbilical channel.

From shells of other Phasianellidae of generally similar shape and size, *Gabrielona* is most readily recognized by its operculum which, externally, has a pronounced marginal ridge and a concave central region. The other two genera have opercula that, externally, are convex. When fully withdrawn into the aperture, the operculum of *Gabrielona* fits shallowly against an axial ridge (or series of faint ridges); the opercula of the other genera fit more deeply against similar, but generally faint, ridges. The axial ridge of *Gabrielona* very rarely is as deep in the aperture as shown in Pl. 52, fig. 3, ar. *Gabrielona* radulae are highly distinctive.

Taxonomic history—When Iredale proposed *Gabrielona*, he did "not think it has really any close relationship with *Phasianella*," even though suggesting that it "may be classed for the present in the family Phasianellidae," and "judging from the shell characters and the operculum and dead animal of the [unnamed] Lord Howe species . . . a Naticoid affinity suggests itself." Characteristically, Iredale did not describe the genus or mention any distinguishing characters other than the naticoid operculum.

Retaining *Gabrielona* in the subfamily Phasianellinae, Thiele (1929) stated it to be doubtfully distinct from *Chromotis* H. and A. Adams, 1863. Following their description of what later came to be the type-species of *Gabrielona*, Catliff and Gabriel (1908) had mentioned a similarity to *Phasianella neritina* Dunker—the type-species of *Chromotis*. Wenz (1938) retained *Gabrielona* as a tentative synonym of *Chromotis*, which he ranked as a subgenus of *Tricolia*. Australian malacologists have disregarded Thiele and Wenz, and have followed Iredale in treating *Gabrielona* as a distinct genus, but without giving reasons.

Finding that *Gabrielona* definitely is not a synonym of *Chromotis* (here considered a synonym of *Tricolia*), I re-established it, accorded it generic rank, and described it for the first time (Robertson, 1958). My study of the radula of "*G. brevis* (Orbigny)" [= *G. sulcifera* Robertson]—not the type species—revealed that it is rhipidoglossate but different from that in other Phasi-

anellidae. Thus, *Gabrielona* does not belong in the Naticidae or any other group with taenioglossate radulae. Absence of a nacreous internal shell layer, and possession of a calcareous operculum necessitated my retaining *Gabrielona* in Phasianellidae, where I arbitrarily placed it in the subfamily Tricolinae.

Relationships—The relationships of *Gabrielona* to other supraspecific taxa in the Phasianellidae are obscure. The resemblances with most other phasianellids—shells of small size with bright colors and complex and variable patterns—seem superficial. In view of the distinct apertural, opercular and radular characters, the genus may not even belong in the family. However, pending more thorough knowledge of relationships within the Trochacea, it seems best to continue to retain *Gabrielona* in the Phasianellidae.

Shell description (abbreviations refer to the drawings)—Attains lengths of 1.1-3.3 mm., widths of 1.1-3.1 mm., and 3.0-4.6 whorls; spire angles 90°-125°; outlines globose; fairly thin to thick, and transparent to opaque. Protoconchs (p) insert to slightly exert, slightly inflated, smooth or with a spiral keel, white, either not demarcated from teleoconch or slightly to fairly prominently demarcated, 0.9-1.2 whorls when demarcated. First whorls 0.20-0.29 mm. in diameter. Subsequent whorls: inflated, rounded in profile; suture slightly impressed. Sculpture predominantly smooth, or with axial plicae or spiral keels, cords and sulci; if present, sculpture most pronounced on second whorl, gradually declining and lacking near periphery or wholly lacking on last whorl of large shells. Periostracum not observed, but very thin layer possibly present. Colors: pinks, reds, or browns, and white. Patterns various, but commonly with subsutural, subperipheral, and periumbilical discordances. Aperture roundly pyriform; outer lip never thickened or everted, thin to thick; callus on upper parietal area thin to thick; a faint to fairly prominent axial ridge (ar) or series of faint ridges within the aperture (against which the fully withdrawn operculum abuts); the ridges fairly variable in position, but never distant from the edge of the outer lip; a fairly faint to fairly pronounced spiral palatal sulcus (ps) high in aperture or near middle, commonly positioned beneath a color pattern feature on external surface and terminating at apertural ridge. Depending on the species, 0-3 faint to rather prominent apertural denticles present, namely 1 palatal and opposite the shoulder in position (pd), 1 on the lower part of the columella (cd₂)—both these on the apertural ridge—

and 1 on the middle part of the columellar lip (cd_1); in species with a lower columellar denticle (cd_2), a faint, broad ridge spirals up the columella; apertural ridge, palatal sulcus, and apertural denticles fairly faint to lacking on small shells. Channel extending into umbilicus (uc) bordered on right by the outer edge of the columellar lip (a slope or an escarpment), and on the left (at an acute angle) by a fairly faint to prominent escarpment arising from the outer edge of the lower half of the columellar lip (abnormally, escarpment absent); umbilicus narrow to wide.

Opercula—Unlike those of the two other genera in the Phasianellidae, the opercula of *Gabrielona* are externally concave. In view of the extreme rarity of live-collected *Gabrielona* in collections, it is convenient that these distinctive opercula are retained—albeit infrequently—in the apertures of some empty shells. The fresh opercula are fairly transparent and white. They all are paucispiral and have fine, irregular spiral and radial growth lines and wrinkles on the external and internal surfaces; this fine sculpture is not shown in the accompanying drawings except where specially prominent.

The external surface has a prominent spiral ridge near the edge (except the non-spiral columellar sector) and a flattish but slightly concave central region which can have a differently textured or sculptured outer, spiral area. On all *Gabrielona* opercula, a callus of varied thickness overlays the upper two-thirds or three-quarters of the central region. This callus covers all or most of the spiral suture, is thickest near the middle columellar edge of the operculum, and its lower margin (marked c on the drawings) is irregular and variable in position and height, with or without a distinct escarpment. Small opercula and the single one known of *G. sulcifera* have a thin or very thin callus and therefore the suture is clearly visible externally—as well as in transparency. In the different species, the spiral ridge and central region are variously sculptured. The non-spiral columellar edge of the operculum is beveled.

The internal surface of the operculum is relatively flat, but the central part of the last whorl near the columellar margin can be slightly concave. The early whorls are slightly raised, and a low, spiral escarpment is at the suture. The central area (at the axis) on all the species with opercula available (*G. nepeanensis*, *G. pisinna*, *G. raunana* [both subspecies] and *G. sulcifera*) is circular, crested at the perimeter, and 0.11-0.14 mm. in diameter—i.e., correlates neither with the

various diameters of the first whorl of the shell, nor with the maximum shell size attained by the various species. This circular central area can be conspicuously smoother, shinier, and more transparent than the remainder of the internal surface, and always bears a low, central boss. The operculum of *G. raunana* (both subspecies) differs from those of the other species in having structural radial lamellae near the edge. Muscle attachment scars are never clearly defined.

When fully withdrawn into the aperture, the operculum abuts against the apertural ridge (ar), and fits closely against the columellar lip as well as the inner surface of the outer lip. In those species possessing the two columellar denticles, the operculum pivots against the columellar lip between these. The slight differences between species in the form of the columellar lip account for the slight differences in the outline of the columellar margin of the opercula.

Anatomy—The very few live-collected specimens available all were preserved dry, so that the bodies were dried out and appressed against the outer shell wall in the aperture. In *G. pisinna*, the gut—distended with whitish, calcareous fragments—was conspicuous, fairly short and U-shaped, arising at the left, extending posteriad and bending to the right at a position about half of a whorl back from the outer lip, and then extending forward to the anus on the right near the outer lip. There was no indication of an enlarged stomach. The mantle edge appeared to be rather thick, but the total volume of the dried body seemed remarkably small. Jaws were not detected but could be present.

Radulae (*Pls. 42 and 57*)—I have been able to study the radulae of only *G. pisinna* and *G. sulcifera*. These differ greatly from other known phasianellid radulae and also from each other. The specimens from which the radulae of the two species were extracted were collected about 9,200 miles apart (New Caledonia and Antigua), and the size difference between their shells is considerable: the shell volume of *G. pisinna* is about 19-fold smaller than that of *G. sulcifera*. Relative to shell size, the radula of *G. pisinna* is rather longer and considerably wider than that of *G. sulcifera*. These differences in actual and relative sizes perhaps account for some of the great differences. In particular, the small absolute size (but not the greater relative width) of the radula in *G. pisinna* could account for the fewer marginals and laterals (3 laterals instead of the 5 in *G. sulcifera*), and the more curved transverse rows of teeth. The "central" of *G. pisinna* possibly is a

pseudocentral comprised of one or two pairs of the original innermost laterals fused together (perhaps also with the original central).

The size differences could not account directly for some of the other interspecific differences: the multicusped laterals of *G. pisinna* and, in *G. sulcifera*, the unwinged central and laterals, the differently-shaped bases of the laterals, and the massive innermost marginals.

The radular differences help to confirm the conclusion reached independently from study of the shells and opercula of the two species, namely that they are distantly related congeners. Lacking information as to the total diversity of *Gabrielona* radulae, their possible ontogenetic changes, the structural consequences of their absolute and relative sizes, and bearing in mind the evolutionary plasticity of *Tricolia* radulae, I consider the radular differences inadequate evidence for separating *G. sulcifera* from *G. pisinna* in a different subgenus or genus.

Relationships within genus—Related pairs of Recent taxa are all allopatric. Only in New Caledonia is more than one species of *Gabrielona* known to occur, and these (*G. pisinna* and *G. raunana*) are distantly related congeners.

The most closely related taxa distinguished here are *G. raunana raunana* and *G. raunana goubini*, which are ranked as subspecies. *G. pisinna* is a dwarf, tropical Indo-Pacific homologue of southeastern Australian *G. nepeanensis*. *G. sulcifera* of the Caribbean perhaps is related, albeit fairly distantly, to the western Pacific *G. raunana*. *G. hadra* is a clearcut fossil precursor of *G. sulcifera*. *G. nepeanensis* and *G. pisinna* seem distantly related to their congeners.

Color and pattern variations—All the species are variable in coloration and pattern: *G. raunana* and *G. nepeanensis* especially so, and *G. pisinna* least of all. The range of coloration of *Gabrielona* is narrower than in each of the other two phasianellid genera. Most of the color and pattern variation in *Gabrielona* is gradational, but a discontinuous color variation is treated under *G. raunana goubini*.

Sexual dimorphism—Not detected conchologically.

Fossil history—The only fossil species known certainly to belong in the genus is "*Tricolia*" *hadra* Woodring from the Bowden Formation (Middle Miocene or possibly Pliocene-Pleistocene) in Jamaica, West Indies.

Distribution of Recent species—Until I transferred a West Indian species to the genus (Robertson, 1958), *G. nepeanensis* (Gatliff and Gabriel),

from southeastern Australia, was the only named species in the genus. An unnamed and cursorily studied *Gabrielona*, mentioned by Iredale (1917), was live-collected in the "sub-littoral" at Lord Howe Island (about 400 miles east of the coast of northern New South Wales, Australia). This locality, shown with a circle on Pl. 39, is between the known distributions of *G. nepeanensis* and the two tropical Indo-Pacific species. Iredale's specimens from Lord Howe were not located at the Australian Museum by Dr. D. F. McMichael in 1962 (letter to Dr. R. T. Abbott dated July 10).

One new tropical Indo-Pacific species, *G. pisinna*, and one new subspecies, *G. raunana goubini*, are described and named here, and the West Indian species to which I misapplied the name *Phasianella brevis* Orbigny is named *G. sulcifera*.

Gabrielona quite possibly occurs in other tropical and subtropical faunal areas, such as West Africa and the Panamic Province. The four known Recent species occur almost exclusively along the coasts of continents and high islands; the only known exception is *G. raunana raunana* Ladd, a subspecies known only as subfossil shells from an atoll.

Abundance—Very few live-collected specimens of any of the species have been available for study: only 7 *G. pisinna* and 1 *G. sulcifera*. The other two Recent species, including the type-species *G. nepeanensis*, are known only from empty, beach worn or subfossil shells, a few with opercula. Thus, the genus appears to be a relict group. Alternatively, it may have been rarely collected if, as I suspect, it mainly lives well below the tidal zone in algae on rocks.

Habitats—Known only from among algae in shallow water (*G. pisinna*) or in sand (*G. sulcifera*); for details see under these species. *G. pisinna* may live as deeply as 8 fathoms; a probably adventitious shell of *G. sulcifera* came from 287 fathoms.

Larval ecology—The fairly small range of variation in the diameter of the first whorls of the six known taxa of *Gabrielona* (0.20-0.29 mm.) and the small sizes presumably indicate that the full-grown larval shells are small and relatively uniform in size, and that the larvae are all pelagic and planktotrophic.

Abnormalities—A striking series of abnormalities possibly caused by an individual living in an unusual habitat is described under *G. sulcifera*. Abnormal growth caused by incrustations are rare in *Gabrielona*; one case is reported under *G. nepeanensis*.

Synonymy-

1917 *Gabrielona* Iredale, Proc. Malac. Soc. London 12:322 [listed], 327. Type-species (by monotypy): *Phasianella nepeanensis* Catliff and Gabriel, 1908.—1929, Thiele, Handb. syst. Weichtierkunde, Jena, 1:70.—1938, Wenz, Handb. Paläozool., Berlin, 6(1)Teil 2 [Prosobranchia], p. 362.—1958, Robertson, Johnsonia 3(37):246-260.

Excluded species—In 1958 (pp. 253, 257), I suggested that three American Miocene (or Pliocene) species might belong in *Gabrielona*: *Tricolia* (*Eulithidium*) *hadra* Woodring, *Didianema* ? *waltonia* Gardner, and *Tricolia* ? *synotoma* Woodring. *T. hadra* is here referred definitely to *Gabrielona*, but subsequent study of the holotypes of the other two species has shown that neither belongs in the Phasianellidae. Two upper Tertiary species from northern Venezuela described as *Gabrielona* are treated under *Excluded Species* on p. 61.

The possible second Western Atlantic Recent species of *Gabrielona* (Robertson, 1958, p. 259), from Brasil, proves upon restudy to be a depauperate, low-spined *Tricolia*.

Gabrielona nepeanensis (Catliff and Gabriel, 1908)

(Pls. 36-39)

Range—Recent: known only from South Australia and Victoria, Australia. Possibly occurs also at Tasmania, but not yet known there.

Chief distinguishing characters—The shell differs from those of all other known species in the genus except *G. pisinna* in having both columellar denticles (cd_1 and cd_2), in lacking axial or spiral sculpture, and in opercular characters (see under *G. raunana* and *G. sulcifera* for differences). Differs from all other species, including *G. pisinna*, by its complex and varying but consistently distinct color patterns (the adults always with a colorless spiral band opposite the palatal sulcus). For detailed differences from *G. pisinna*, the most similar species, see under that species.

Abundance—36 shells from beach sand available, 1 with operculum in place in aperture; none live-collected (probably lives below the tidal zone).

Abnormal shell—One shell (Pl. 36, fig. 6) has a double outer lip near the suture, a columellar callus slightly detached from the palatal area, and the upper columellar denticle (cd_1) fainter than usual. Some incrustation must have interfered with normal growth.

Shell description—Attains length of 1.9 mm., width of 1.7 mm., and 3.9 whorls; spire angle $95^\circ-105^\circ$; length invariably equals or exceeds width (except for small shells); fairly thick but slightly translucent to fairly transparent. Protoconch insert, slightly inflated, smooth, white, not demarcated from teleoconch. First whorl 0.24-0.28 mm. in diameter. Penultimate and last whorls: slight flattening below suture but no distinct shoulder (Pl. 38, fig. 1); surface smooth except for axial growth lines and slight wrinkles, fairly shiny. Colors: pale to dark pink (rarely, tinged with orange), and white. Patterns: alternating pink and white subsutural marks, each becoming divided by a virtually colorless spiral band directly opposite the palatal sulcus; 9-12 paired pink marks on last whorl; predominant below subsutural area: axially aligned wavy pink stripes or irregular marks; subperipheral series fairly faint pink and white marks; inner umbilical area colorless, surrounded by spiral series short white axial stripes (commonly, partially coalesced); rarely, zigzag pale pink stripes or irregular marks entirely replace usual pattern (Pl. 36, figs. 3-4). Outer lip and callus on upper parietal area fairly thin; no palatal denticle; palatal sulcus high in aperture; both columellar denticles present, most prominent on large shells (Pl. 38, fig. 2). Columellar lip thickened adjacent to central part umbilical channel, and an escarpment present; escarpment to left of umbilical channel fairly faint to prominent, arising fairly low off the outer edge of columellar lip; umbilicus narrow to fairly wide.

Shell measurements (mm.)—

length	width	no. whorls	
1.92	1.66	3.9	large; South Australia
1.56	1.46	3.3	average; South Australia
0.80	0.87	2.5	smallest; South Australia



Plate 37. *Gabrielona nepeanensis* (Catliff and Gabriel). Victoria, Australia. Original figures of holotype (from Catliff and Gabriel, 1908, pl. 21, figs. 9-10), enlarged. Both $\times 20$. Fig. 1 incorrectly shows a prominent shoulder (compare Pl. 36, fig. 10).

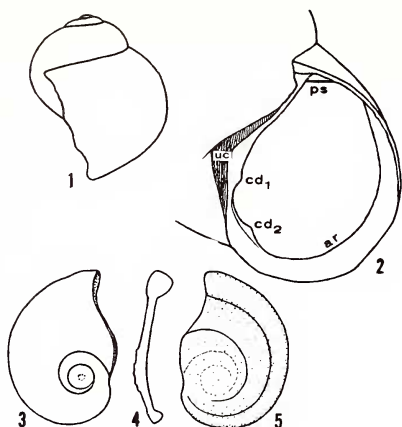


Plate 38. *Gabriellona nepeanensis* (Gatliff and Gabriel). Fig. 1. Outline of large shell, x17. Fig. 2. Aperture, x33; ar, apertural ridge; cd_1 and cd_2 , upper (outer) and lower (inner) columellar denticles (respectively); ps, palatal sulcus; uc, umbilical channel. Figs. 3-5. Operculum. Internal surface, longitudinal section, and external surface (respectively). All x33.

Operculum—(Pl. 38, figs. 3-5). Only a single, abraded operculum of this species has been available, and it has been difficult to determine the sculpture of its external surface. The crest of the spiral ridge near the edge seems to be rounded, and on the central region—between the outer, spiral area and the central area—there is a low, spiral ridge extending to a prominence on the non-spiral columellar margin. The outline of the columellar margin at the junction of the spiral and non-spiral sectors is shallowly concave. Otherwise the operculum of *G. nepeanensis* seems to be like that of *G. pisinna*, only larger; both are fairly thin.

Synonymy—

- 1908 *Phasianella nepeanensis* Gatliff and Gabriel, Proc. Roy. Soc. Victoria, n.s., 21(1): 366, pl. 21, figs. 9-10 [reproduced here, Pl. 37] (Flinders, Western Port; Ocean Beach, near Point Nepean [both Victoria, Australia]).
—1917, Iredale, Proc. Malac. Soc. London 12(6): 322 [listed], 327 [the only named species included in *Gabriclona* but not formally transferred].
- 1938 *Gabriellona nepeanensis* (Gatliff and Gabriel). Cotton and Godfrey, Malac. Soc. South Australia Publ. 1: 9; 1945, Cotton, Trans. Roy. Soc. South Australia 69(1): 165; 1958, Robertson, Johnsongia 3(37): 257, pl. 137, figs. 2-3, pl. 140, fig. 1; 1959, Cotton, South Australian Mollusca, Archaeogastropoda, Adelaide, pp. 270-271, fig. 185 [shell shape highly inaccurate], p. 347 [listed].

Types—The holotype of *Phasianella nepeanensis* Gatliff and Gabriel (Pl. 36, fig. 10; Pl. 37) is now at the National Museum of Victoria (no. F543), Melbourne, Australia. A small paratype is at the Australian Museum (no. C.45057), Sydney (Robertson, 1958, pl. 140, fig. 1). Gatliff and Gabriel did not mention the number of specimens available to them, and recorded the species from two localities 23 miles apart. Cotton and Godfrey (1938) selected "Flinders, Victoria" as the type-locality. However, in 1945 and subsequently, Cotton has stated that the type-locality is "near Point Nepean," whence (judging by the specific name) the holotype came.

Locality records (see map, Pl. 39; literature and uncertain records circled)—SOUTH AUSTRALIA: Port Lincoln ("apparently *nepeanensis*," Iredale, 1917; Cotton, 1945); Mouth of Middle River, N. coast Kangaroo I. (from beach sand, 1954, B. Daily, via M. F. Glaessner and G. L. Harrington); Port Adelaide (Calvert Coll., both ANSP); Robe (Cotton, 1945). VICTORIA: Port Fairy (in beach sand, 1923, H. A. Pilsbry, ANSP); ocean beach near Point Nepean [38 mi. S.W. of Melbourne] (Gatliff and Gabriel, 1908; Natl. Mus. Vict.; Austral. Mus.); Flinders [47 mi S. of Melbourne], Western Port (Gatliff and Gabriel, 1908).

All three of the circled locality records in South Australia are questionable because Cotton (1945, 1959) mentioned having difficulty distinguishing *G. nepeanensis* from "*Pellax virgo*," and the locality data with all the available specimens except one juvenile shell from Kangaroo Island seem not wholly reliable either. A large series (30 shells) is from the Calvert Collection (collector not recorded), labeled "Pt. Adelaide" is suspect because this is the largest port in the area.

Gabriellona pisinna Robertson, new species

(Pls. 39-42)

Range—Recent: known only from Mauritius, Indian Ocean, and New Caledonia, eastern Melanesia. Perhaps widespread in the tropical Indo-Pacific around high islands.

Chief distinguishing characters—The shell, usually less than 1 mm. in length, is full-grown at a smaller size than in any other known phasianellid. It resembles young *G. nepeanensis* in size and number of whorls. (Further resemblances: has both columellar denticles, an unsculptured surface, and a similar operculum.) That *G. pisinna* is full-grown at a smaller size than *G. nepeanensis* is shown by the complete development on the larger shells of the lower columellar denticle (cd_2). Further differences from *G. nepeanensis*: first whorl smaller; spire lower (except for some

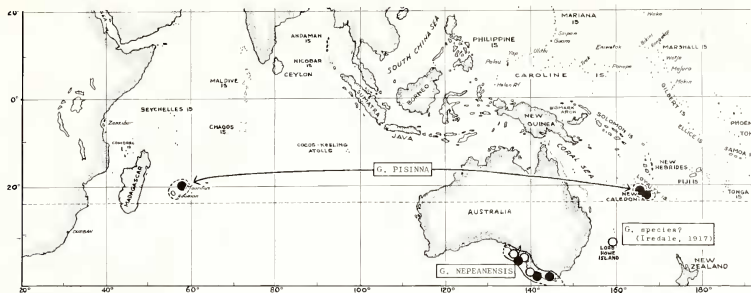


Plate 39. Geographical distributions and records of *Gabriclona nepeanensis* (Gathil and Gabriel), *Gabriclona* species? (Iredale, 1917), and *Gabriclona pisinna* Robertson, which large shells, the width of *G. pisinna* invariably exceeds the length); aperture smaller than in young *G. nepeanensis* of comparable size (compare Pl. 40 with Pl. 36, fig. 1); color patterns different (finer), and reddish coloration darker.

Relationships—A dwarf, tropical homologue of *G. nepeanensis*, which might need to be ranked as a subspecies if the form occurring at Lord Howe Island (map, Pl. 39) is intermediate (see p. 44).

Abundance—68 specimens available: 2 empty shells from Mauritius (1 with operculum), and 66 specimens from New Caledonia (10 with opercula, 7 of these live-collected).

Habitat—All 7 of the live-collected specimens came from washings from algae collected in 0-3 ft. on Récif Ricaudy, New Caledonia, on rocks near shore on the fringing reef. An empty but fresh shell with 4 drill holes and an operculum in place in the aperture came from a depth of 8 fathoms at Mauritius (see under *Locality records*). (Many of the shells have these drill holes.)

Shell description—Attains length of 1.1 mm., width of 1.1 mm., and 3.0 whorls; spire angle 115° - 125° ; width exceeds length (excepting some large shells); fairly thin and translucent to transparent. Protoconch insert, slightly inflated, smooth, white, not demarcated from teleoconch. First whorl 0.20-0.24 mm. in diameter. Penultimate and last whorls: slight flattening below suture but no distinct shoulder (Pl. 41, figs. 2-3); surface smooth except for axial growth lines and slight wrinkles, shiny; fine spiral sulci on base of small shells (Pl. 41; fig. 1). Colors: dark pink to bright red (rarely, tinged with amber [faded?]), and white. Patterns: white spiral band below the suture, coalescing with variably-shaped white subsutural patches (7-9 on last whorl), lower

perhaps is widespread in the tropical Indo-Pacific but which presently is known only from the two areas 7300 miles apart.

edges of which are slightly below or directly opposite the palatal sulcus; pink or red marks or non-axial stripes alternate with white subsutural patches; predominant below subsutural area: fairly regular axial or very steeply ascending dark stripes; subperipheral series of white marks alternating with non-axial dark stripes or axially paired marks; umbilical area closely surrounded by spiral series of short white axial stripes (fairly commonly, partially coalesced); very rarely, subsutural patches and subperipheral white marks coalesce into irregular axial white bands (Pl. 40, fig. 2). The aperture averages relatively

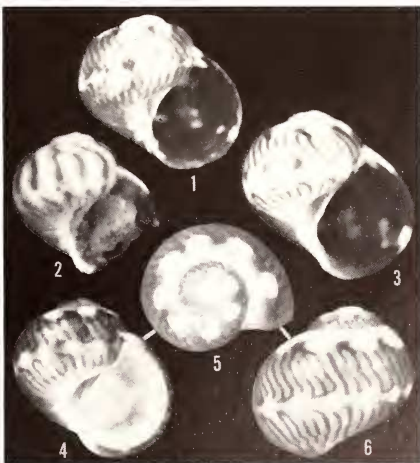


Plate 40. *Gabriclona pisinna* Robertson. Fig. 1. Mauritius. Figs. 2-6. New Caledonia. Figs. 4-6. Holotype. All $\times 30$.

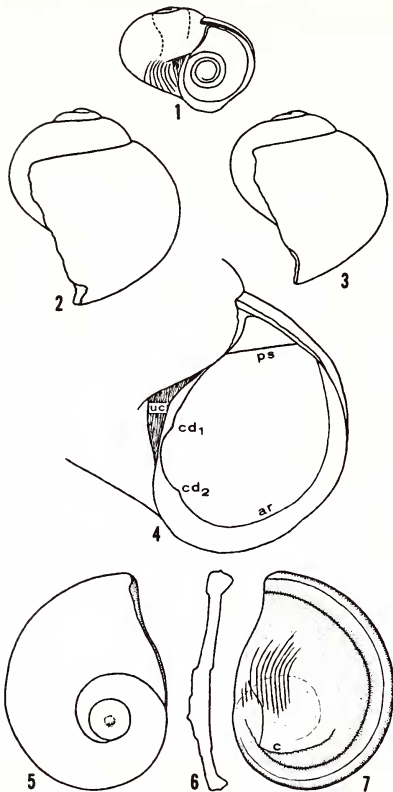


Plate 41. *Gabrielona pisinna* Robertson. Fig. 1. Smallest specimen, x60. Figs 2-3. Outlines of largest shells, both x33. Fig. 2. Unusually high-spired shell. Fig. 4. Aperture, x60; ar, apertural ridge; cd₁ and cd₂, upper (outer) and lower (inner) columellar denticles (respectively); ps, palatal sulcus; uc, umbilical channel. Figs. 5-7. Operculum. Internal surface, longitudinal section, and external surface (respectively); c, lower edge of callus. All x60.

slightly wider than in *G. nepeanensis*. Outer lip and callus on upper parietal area thin; no palatal denticle; palatal sulcus high in aperture, slightly variable in position (commonly, fairly faint); both columellar denticles present, most prominent on large shells (Pl. 41, fig. 4). Columellar lip slightly thickened adjacent to central part umbilical channel, and an escarpment, when present, faint; escarpment to left of umbilical channel fairly prominent, arising fairly low off outer edge columellar lip; umbilicus fairly wide.

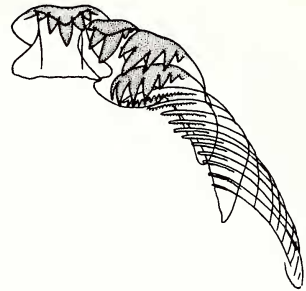


Plate 42. *Gabrielona pisinna* Robertson. Half of one transverse row of radular teeth, showing (from left to right) the 5-cusped central (or pseudocentral?), the three laterals on the right side, and the entire row of marginals. The cusps of the central and laterals are stippled. New Caledonia. x1050.

Shell measurements (mm.)—

length	width	no. whorls	
1.09	1.10	3.0	largest; New Caledonia
0.91	0.93	2.8	holotype; New Caledonia
0.70	0.75	2.6	average; Mauritius
0.34	0.42	1.7	smallest (Pl. 41, fig. 1); New Caledonia

Operculum—(Pl. 41, figs. 5-7)—The spiral ridge near the edge on the external surface of the fairly thin operculum is sharply crested except near the columellar margin where it is rounded. The inner margin of the ridge is angled or rounded. The central region has an outer, spiral area with a mat surface contrasting with a shiny, more transparent central area. The single operculum available from Mauritius differs from those from New Caledonia in having a faint spiral ridge between the two areas (like that of *G. nepeanensis*). Fairly prominent wrinkles parallel to the non-spiral columellar margin are present to the left of the central part of the callus. The lower margin of the callus (c) varies in position.

Radula (Pl. 42; 2 studied)—Attains length of 0.37 mm., width of 0.08 mm., and with as many as 20 very strongly curved transverse rows of teeth (including a few nascent rows). Central (or pseudocentral?) 5-cusped, laterally winged anteriorly, and with posterolateral projections on the base. (Three laterals, each with long pointed cusps (the two innermost generally with 5 cusps, and the outermost with 6); the two outermost laterals have the largest distal portions, and the outer lateral is positioned posterior (rather than lateral) to the morphologically middle lateral; the

base of the innermost lateral bears a posterolateral peg that fits into the middle of the inner edge of the base of the middle lateral, and the two outermost laterals have large bases that extend posterolaterally beneath the marginals. As many as 13 pairs of marginals (lowest cost 10), each row widely overlapping the row posterior. All the marginals have elongate distal portions, and the innermost of these are serrate on the outer (posterior) edge; the serrations become finer outwards and are absent altogether on the small outermost teeth.

Types—The holotype (Pl. 40, figs. 4-6), from Récif Ricaudy, near Noumea, New Caledonia, is at the Academy of Natural Sciences of Philadelphia (no. 301611). So also are paratypes from the type-locality (no. 271062) and from other localities: Récif de Gatope, New Caledonia (nos. 267567 and 267568), and Mauritius (nos. 273188 and 273328). Paratypes from New Caledonia will be distributed to USNM, MCZ, BM, and IrSnB (2 shells each).

Derivation of new name—Latin, *pisinnus*, little.

Locality records (see map, Pl. 39)—MAURITIUS: $\frac{3}{4}$ mi. N.N.E. of Flec en Flacq Pt. (1-10 ft., from *Caulerpa* washings, Nov., R.E.M. Ostheimer & V. Orr Maes, Sta. M 203); Black River Bay, 1 mi. W.N.W. of mouth Black River, both W. coast (dredged 8 fms. [1 empty but fresh shell], coarse sand, broken shell, very little weed, Nov. 5, both 1960, R.E.M. Ostheimer, J. de B. Baissac & V. Orr Maes, Sta. M 208, both ANSP). NEW CALEDONIA: Grand Récif de Gatope, $\frac{7}{8}$ mi. W. of Voh (dredged 6-18 ft., inner edge of barrier reef, sand, weed, coral rubble, Dec. 31, 1960 & Jan. 2, 1961, Stas. K 538 & K 539); E. end Récif Ricaudy, $\frac{2}{4}$ mi. S.E. of Nouméa (0-3 ft., Jan. 11, 1961, both G. & M. Kline & V. Orr Maes, Sta. K 553, both ANSP).

Gabrielona raunana Ladd, 1966

(Pls. 43-50)

Range—Recent: known only from Eniwetok (an atoll), northwestern Marshall Islands (*G. raunana raunana* Ladd), and from the Loyalty Islands and New Caledonia (all high islands), eastern Melanesia (*G. raunana goubini* Robertson).

Chief distinguishing characters—This is the only species in the Phasianellidae having a shell with prominent axial sculpture. The plicae are most prominent and regularly arranged on the second whorl, and are obscure or absent at and near the periphery of the last whorl of large shells. Also differs from other species in the genus as follows: spiral keel on protoconch; all apertural denticles lacking; operculum with obliquely radial sulci on part of external surface, and with

structural radial lamellae at and near the spiral outer edge. The outlines of the shells and color patterns of both subspecies are distinct from each other and from those of the other species.

Remarks—No live-collected specimens are available of either subspecies; most of the shells are beach worn or subfossil. *G. raunana*, known only from populations in two areas slightly more than 2,000 miles apart, seems thus to be a relict species.

Shell descriptions, Types, Locality records, etc.—See under *G. raunana raunana* and *G. raunana goubini*.

Operculum (Pl. 44)—Only 2 opercula of *G. raunana raunana* and 8 of *G. raunana goubini* are available, and because all these are abraded or corroded—making description and illustration of the original sculpture difficult—and because it is doubtful whether the seeming slight differences between the two subspecies are real, they are discussed together here. The operculum in best condition is a small one from *G. raunana raunana*.

Relative to those of *G. nepeanensis* and *G. pisinna*, the operculum of *G. raunana* (both subspecies) is thick and comprises fractionally more whorls (comparing opercula of the same size). The external surface has a central region with an outer, spiral area distinctive in having prominent, obliquely radial sulci (irregular and varying in spacing), and a central, smoothish area with a fairly thick callus. The crest of the spiral ridge is

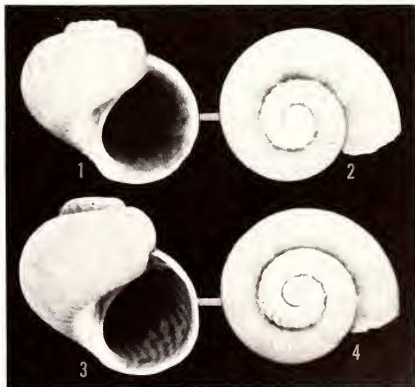


Plate 43. *Gabrielona raunana* Ladd. Thinly coated with magnesium oxide to accentuate the sculpture and obscure the color pattern. Figs. 1-2. *G. raunana raunana* Ladd. Eniwetok, Marshall Islands. Figs. 3-4. *G. raunana goubini* Robertson. Lifou, Loyalty Islands. All $\times 20$.

near the outer edge, and (at least on *G. raunana raunana*) its whole surface is irregularly wrinkled and knobbed, the wrinkles tending to be aligned with the adjacent obliquely radial sulci.

The erosion of the external surface makes several features obscure. The spiral ridge is strongly abraded on all the opercula available from *G. raunana goubini*. On all but one of these there is a deep but irregular central pit that may be an erosional feature; this is margined by an irregular but steep escarpment at the lower margin of the callus (c). On the unpitted operculum of *G. raunana goubini*, two spiral sulci are near the center and there is no steep escarpment bordering the callus; this perhaps is the uneroded original sculpture.

Seen in transparency, near the outer edge of the operculum are structural radial lamellae at right angles to the horizontal plane of the operculum. These are closely and regularly spaced and extend a uniform distance from the edge. Most prominent at the edge of the operculum of *G. raunana raunana*, these project from the surface as external lamellae, thus causing the outline to be finely notched. These external lamellae perhaps are erosional features.

Gabrielona raunana raunana Ladd, 1966

(Pl. 43, figs. 1-2; Pl. 44, figs. 4-6; Pls. 45-47)

Range—Recent: known only from subsurface deposits on Eniwetok Atoll, northwestern Marshall Islands (obtained from drillings). Perhaps widespread at atolls in Micronesia or the whole tropical northwest Pacific.

Chief distinguishing characters—The shell of this subspecies has fairly regularly spaced but

commonly coalesced colorless or white spots, each one surrounded by 6 others. More differences are given under *G. raunana goubini*. Sculpture is almost identical in the two subspecies.

Abundance—32 subfossil shells available, 1 with an operculum in place in the aperture; 1 loose operculum.

Shell description—Attains length of 2.1 mm., width of 2.1 mm., and 3.4 whorls; spire angle 110° - 125° ; width invariably equals or exceeds length; fairly thick to fairly thin and opaque to fairly transparent. Protoconch insert, smooth except for slightly descending spiral keel, white, slightly demarcated from teleoconch, 0.9 whorl. First whorl 0.26-0.29 mm. in diameter. Penultimate and last whorls: flattening below suture, and faint shoulder (Pl. 46, fig. 1). Sculpture of second whorl: 18-30 strong axial plicae, convex towards outer lip, highest, most sharply crested and most widely spaced on first half where a fairly prominent to fairly obscure spiral cord extends from the keel on protoconch. On later whorls plicae smaller, crests rounded, more closely spaced, and less regular in arrangement and structure, commonly with intercalated secondary plicae below suture and with divarications and anastomoses below periphery. A faint spiral cord surrounds the umbilical area of young shells; rarely, faint reticulations on base of medium-sized shells. On last whorl irregular axial plicae most prominent below suture and on base, absent near periphery of large shells where surface is smooth except for axial growth lines. Surface shiny. Colors: pale (faded?) to fairly pale pink or yellowish brown, and white. Patterns: more or less quadrate pink or brownish subsutural patches (6-10 on last whorl), lower edges directly opposite palatal sulcus; surface almost entirely covered with fairly regularly spaced spots, each one sur-

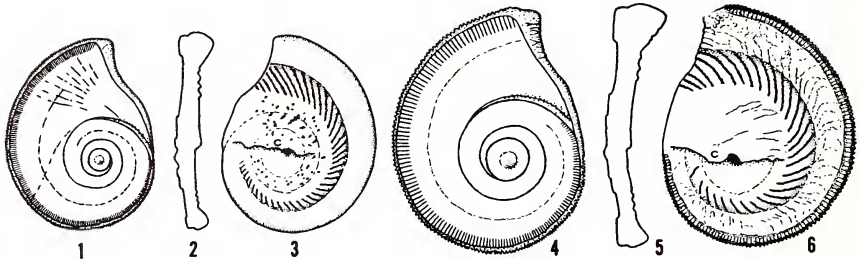


Plate 44. *Gabrielona raunana* Ladd. Opercula. Figs. 1-3. *G. raunana goubini* Robertson, x33. Figs. 4-6. *G. raunana raunana*, x60.

Internal surface, longitudinal section, and external surface of each; c, lower edge of callus.

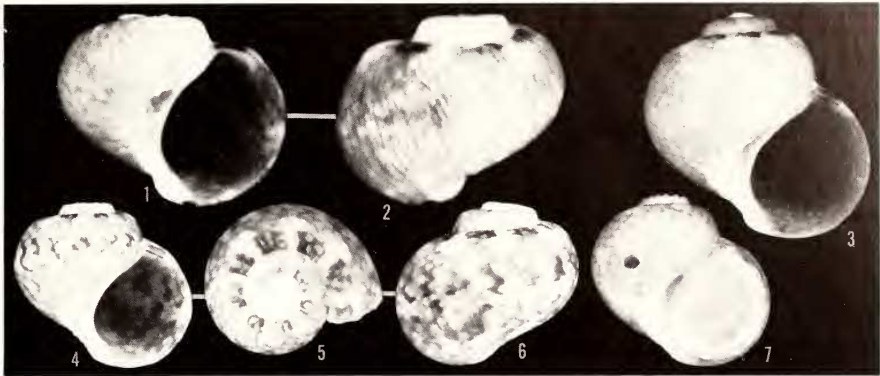


Plate 45. *Gabrielona raunana raunana* Ladd. Subsurface Recent deposits, Eniwetok Atoll, Marshall Islands. Fig. 7. Holotype. Figs. 1-2, x40; Figs. 3-7, x20.

rounded by 6 others; spots white in pale areas alternating with subsutural patches and colorless elsewhere except (somewhat commonly) for subperipheral spiral series and (rarely) spiral series on base; commonly: spots irregularly coalesced; ground color pale; fairly commonly: subperipheral spiral series irregular, slightly darkened markings alternating with white-spotted areas; closely surrounding umbilicus: spots variously coalesced into irregular, steeply descending white stripes on colorless ground; fairly rarely: wavy, axial darkened bands extending from subsutural patches to base; rarely: almost a uniform pink with no spots near periphery. Outer lip and callus on upper parietal area somewhat thin to fairly thick; no palatal denticle; palatal sulcus high in aperture,

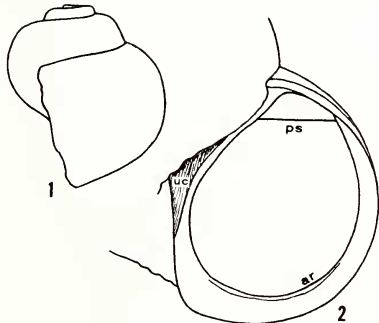


Plate 46. *Gabrielona raunana raunana* Ladd. Fig. 1. Outline of large shell, x17. Fig. 2. Aperture, x33; ar, apertural ridge, ps, palatal sulcus; uc, umbilical channel.

neither columellar denticle present (Pl. 46, fig. 2). Columellar lip not thickened, and steep slope into umbilical channel but no escarpment; escarpment to left of umbilical channel prominent, arising quite high off the outer edge of the columellar lip; umbilicus fairly narrow to wide (Pl. 46, fig. 2).

Shell measurements (mm.)—

length	width	no. whorls	
2.09	2.09	3.4	largest
1.60	1.67	3.1	average; holotype
0.89	1.07	2.4	smallest

Operculum—See under *G. raunana* (species).

Synonymy—

1966 *Gabrielona raunana* Ladd. [U.S.] Geol. Surv. Prof. Paper 531, pp. 13 & 17 [listed], 54 [described], pl. 10, figs. 1-5 (Recent, Eniwetok Atoll).

Types—The holotype (Pl. 45, fig. 7), out of a drilling from 20-45 ft. below land surface Elugelab, Eniwetok, is at the United States National Museum (no. 648319), Washington, D.C. So also are all the paratypes except 3 donated to the Academy of Natural Sciences of Philadelphia (no. 302131).

Locality records (see map, Pl. 47)—MARSHALL ISLANDS: Elugelab (20-60 ft. deep), Parry (30-45 ft., 90-110 ft., 1865-1895 ft.), and Mujinkarikku (35½-10½ ft.), all Eniwetok Atoll (from 8 drill holes in Recent subsurface deposits; 30 shells and 1 loose operculum at depths of 20-60 ft., 1 shell from 90-110 ft., and 1 probably adventitious shell in lower Miocene strata at 1865-1895 ft., all about 1952, I.I.S. Ladd, USNM & ANSP). For an account of the drilling operations which yielded most of the specimens, see Ladd and Schlinger (1960, [U.S.] Geol. Surv. Prof. Paper 260-Y, pp. i-iv, 863-905).

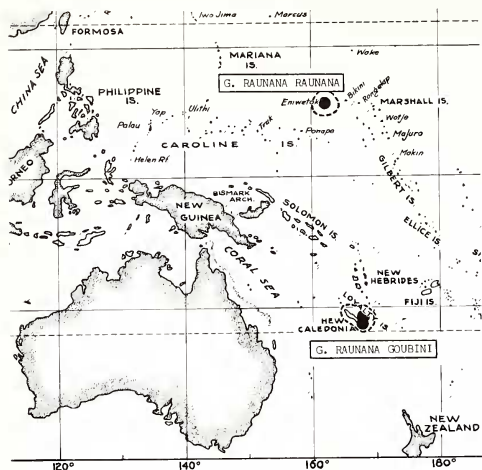


Plate 47. Geographical records of *Gabrielona raunana raunana* Ladd and *Gabrielona raunana goubini* Robertson.

***Gabrielona raunana goubini*
Robertson, new subspecies**

(Pl. 43, figs. 3-4; Pl. 44, figs. 1-3; Pls. 47-50)

Range—Recent: known only from Lifou, Loyalty Islands, and Île des Pins, New Caledonia, eastern Melanesia. Perhaps widespread around high islands in Melanesia or the whole tropical southwest Pacific.

Chief distinguishing characters—The shell differs from that of the nominate subspecies as follows: spire averages higher and aperture relatively smaller; first whorl averages smaller; plicae finer on medium-sized shells; color pattern almost invariably with steeply descending pink or yellowish brown stripes, and white subsutural patches commonly ring-shaped.

Abundance—1,116 shells available, 8 with an operculum in place in the aperture. All the specimens were sorted from beach sand; some are freshly dead, but many are worn or broken and some are bleached.

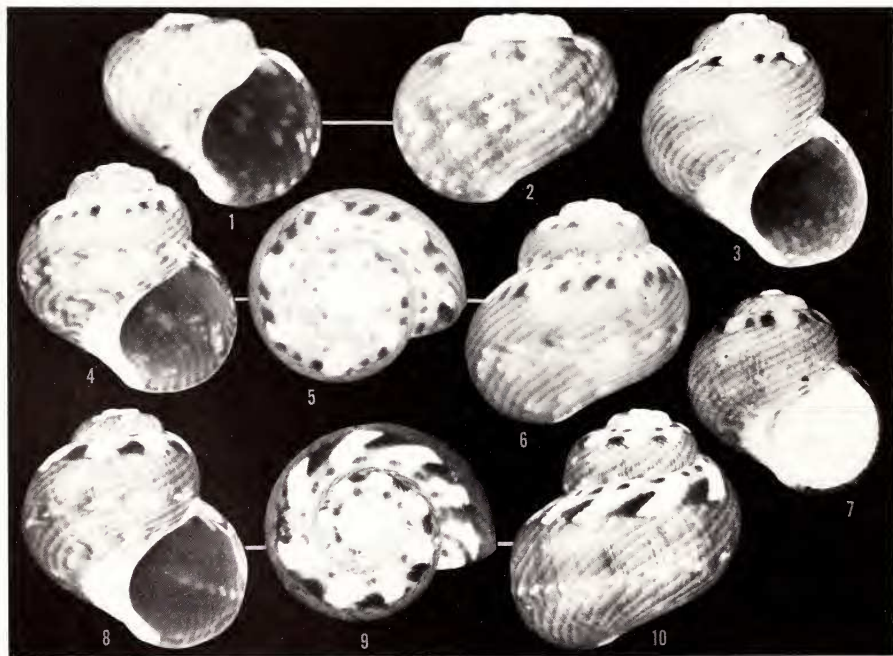


Plate 48. *Gabrielona raunana goubini* Robertson. Lifou, Loyalty Islands. Fig. 7. Holotype. Figs. 1-2, x40, Figs. 3-10, x20.

Remarks—In view of the apparent abundance of this subspecies in beach sand it is remarkable that it has not been named previously, in spite of rather extensive study of small marine shells from the Loyalty Islands (Tomlin, 1936, Proc. Malac. Soc. London 22(3): 145-152).

Color variation—Most of the shells have pink markings; an infrequent color form is entirely devoid of pink and has pale yellowish brown markings; intermediates have the pink followed by the yellowish markings. Only a few shells were not readily sorted into one of these three categories. Of the 1,088 shells from Lifou, approximately 938 (86%) are the pink form, 112 (10%) are intermediates, and 38 (4%) are the yellowish form. The frequencies of the three color forms are comparable in the much smaller sample (28 shells) from Ile des Pins: 18 (64%) pink, 7 (25%) intermediates, and 3 (11%) yellowish.

Shell description—Attains length of 2.4 mm., width of 2.2 mm., and 3.9 whorls; spire angle 90°-115°; width fairly commonly exceeds length; fairly thick but slightly translucent to fairly transparent. Protoconch like that of *G. raunana raunana*. First whorl 0.23-0.28 mm. in diameter. Subsequent whorls: flattening below suture, and faint to obscure shoulder (Pl. 50, fig. 1). Sculpture like that of *G. raunana raunana* except plicae (Pl. 50, fig. 2) finer, spiral cord on first quadrant(only) of second whorl faint or absent, and no reticulations on base of medium-sized shells. Surface shiny. Colors: fairly pale to dark pink,

pale yellowish brown, and white. Patterns: variably-shaped white subsutural patches (7-9 on last whorl), commonly ring-shaped with axial stripe extending to suture, lower edges near or directly opposite palatal sulcus; white subsutural patches alternating with variable yellowish brown or pinkish marks; predominant below subsutural area: steeply descending pink and/or yellowish brown stripes; commonly: subperipheral series small, irregular white marks alternating with slightly darkened pinkish or yellowish brown marks; fairly commonly: similar series small white marks on base, with darkened pinkish marks; closely surrounding umbilicus: steeply descending, partially coalesced white stripes; very rarely: all descending stripes zigzag or broken into irregular marks (Pl. 49). Aperture averages slightly narrower and relatively smaller than that of *G. raunana raunana*; outer lip somewhat thick; callus on upper parietal area thin to fairly thick; apertural denticles, palatal sulcus, columella and umbilical area as in *G. raunana raunana*, except escarpment to left of umbilical channel fairly faint to prominent and umbilicus narrow to quite wide.

Shell measurements (mm.)—

length	width	no. whorls	
2.42	2.16	3.9	largest
1.92	1.80	3.5	average; holotype
0.90	1.01	2.6	smallest

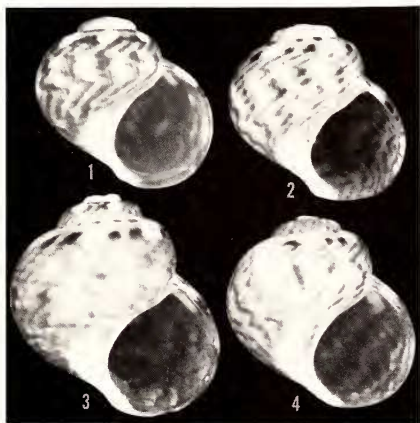


Plate 49. *Gabrielona raunana goubini* Robertson. Rare color patterns, Figs. 1-3. Lifou, Loyalty Islands. Fig. 4. Ile des Pins, New Caledonia. All x20.

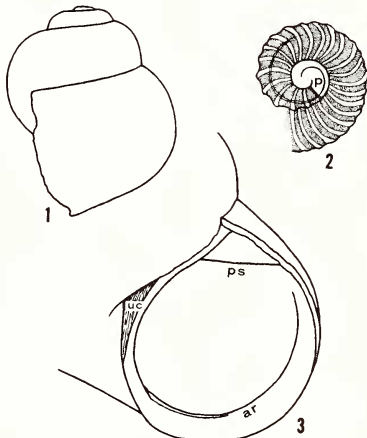


Plate 50. *Gabrielona raunana goubini* Robertson. Fig. 1. Outline of large shell, x17. Fig. 2. Apex, x33; p, protoconch. Fig. 3. Aperture, x33; ar, apertural ridge; ps, palatal sulcus; uc, umbilical channel.

Operculum—See under *G. raunana* (species).

Types—The holotype (Pl. 48, fig. 7) from Lifou, Loyalty Islands, is in the Dautzenberg Collection at the Institut royal des Sciences naturelles de Belgique, Brussels. So also are 1,102 paratypes from Lifou and Ile des Pins. Ten more paratypes from Lifou are retained at the Academy of Natural Sciences of Philadelphia (no. 302624), and 3 from Lifou have long remained unidentified at the United States National Museum (no. 422601), Washington, D. C.

Derivation of new name—Named for Goubin, the collector who meticulously sorted out from beach sand 1,085 of the shells.

Locality records (see map, Pl. 47)—LOYALTY ISLANDS: Ile Lifou (Goubin, IrSnB & ANSP; Moss, USNM). NEW CALLEDONIA: Ile des Pins (Lambert, IrSnB).

Gabrielona hadra (Woodring, 1928)

(Pls. 51-53)

Range—Middle Miocene or Plio-Pleistocene: known only from the Bowden Formation, southeastern Jamaica, Greater Antilles. Presumably was widespread in the Caribbean area. (On apparent endemism in the Bowden Formation, see W. P. Woodring, 1965, *Science* 148 (3672): 961-963.)

Chief distinguishing characters—The shell attained a larger size than that of any Recent species in the genus. *G. hadra* is distinct also in having a deeply embayed columellar lip below the junction with the palatal wall. Otherwise, *G. hadra* closely resembles *G. sulcifera* (the sculpture of the second whorl is similar, the palatal



Plate 51. *Gabrielona hadra* (Woodring). Middle Miocene (or Plio-Pleistocene), Bowden Formation, Jamaica. Fig. 4. Large-

st known specimen of any *Gabrielona* (surface eroded). Figs. 5-7. Holotype. All $\times 20$.

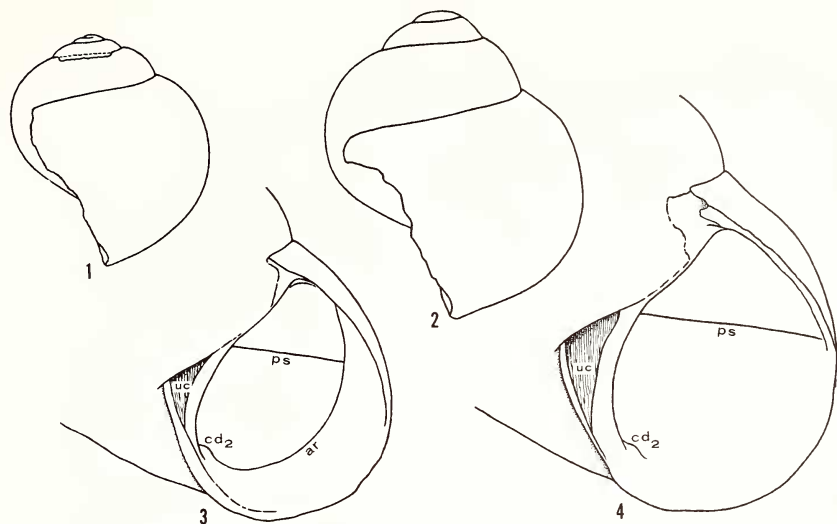


Plate 52. *Gabrielona hadra* (Woodring). Figs. 1-2. Outlines of shells, showing variation, both $\times 17$. Fig. 2. Largest known specimen of any *Gabrielona* (surface cross-hatched). Figs. 3-4. Apertures, showing variation; both $\times 33$; ar, apertural ridge; cd₂, lower (inner) columnellar denticle; ps, palatal sulcus; uc, umbilical channel. Figs. 1 and 4. Holotype.

sulcus is near the middle of the aperture, and only the lower columnellar denticle (cd₂) is present. Additional differences from *G. sulcifera*: first whorl averages smaller; spiral sculpture on second whorl less prominent, disappearing before the beginning of the third whorl; no spiral sulci on later whorls; color patterns different.

Abundance—21 shells currently available, none with opercula (36 paratypes not available; see under *Types*).

Remarks—This is the only known fossil species undoubtedly belonging in the genus, and clearly is a precursor of the Recent Caribbean *G. sulcifera*. The relative abundance of *G. hadra* in the Bowden Formation is noteworthy in view of the rarity of its living descendant.

The surface of the shell is most resistant to corrosion where there were white markings, which on some shells are preserved as low projections.

Shell description—Attained length of 3.3 mm., width of 3.1 mm., and 4.6 whorls; spire angle 95°-120°; length invariably exceeds width (except possibly for small shells), but outline variable; fairly thick to thick, and opaque (fresh

shells might be translucent or transparent). Protoconch slightly exsert, slightly inflated, smooth, whitish, slightly demarcated from teleoconch, 1.1-1.2 whorls. First whorl 0.23-0.25 mm. in diameter. Penultimate and last whorls: slight flattening below suture and faint shoulder (Pl. 52, figs. 1-2). Sculpture of second whorl: 3 fairly low spiral keels on first quadrant following protoconch, each about equal in prominence; keels gradually becoming spiral cords, commonly with 2 more cords intercalated; very fine axial threads; all sculpture gradually disappearing on third or fourth quadrant, commonly with no spiral sulci; on later whorls surface wholly smooth except for fine axial growth lines. Surface shiny. Colors: pale (faded?) reddish or purplish brown, and white. Patterns: irregularly shaped whitish subsutural patches (8-11 on last whorl), alternating with brownish areas; lower edges of patches irregular, not correlated with position of palatal sulcus; predominant below poorly demarcated subsutural area: ground color pale reddish brown; 2-3 spiral series irregular white markings (commonly crescentic, concave towards outer lip) that are smaller than the subsutural patches; 2 of these series near (above and below) periphery (upper one fairly uncommonly absent), and third on base (6-9 markings); umbilical area commonly tinged with purple. Aperture shape like

that of *G. sulcifera*; outer lip fairly thin to thick; callus on upper parietal area thin to thick; palatal denticle absent; apertural ridge (ar) shallow to fairly deep in aperture (Pl. 52, fig. 3); palatal sulcus near middle of aperture; upper columellar denticle (ed_1) absent; lower columellar denticle (ed_2) present, prominent or low and wide (Pl. 52, figs. 3-4). Columellar lip not thickened, deeply embayed below junction with palatal wall; fairly shallow slope into wide umbilical channel; escarpment to left of umbilical channel prominent, arising fairly high to high off outer edge columellar lip, and commonly the right-hand edge of a ridge; umbilicus wide.

Shell measurements (mm.)—

length	width	no. whorls	
3.30	3.06	4.6	largest
2.51	2.44	4.2	average; holotype
2.10	2.04	4.0	fairly small

Synonymy—

1928 *Tricolia (Eulithidium) hadra* Woodring, Carnegie Inst. Washington Publ. 385 (Miocene Mollusks from Bowden, Jamaica; Part II), pp. 16 [name listed], 420-421, pl. 34, figs. 10-11.—1958, Robertson, *Johnsonia* 3(37): 253, 257 [provisionally referred to *Gabrielona*].

Types—The holotype of *Tricolia (Eulithidium) hadra* Woodring (Pl. 51, figs. 5-7), from near Bowden, Jamaica, is at the United States National Museum (no. 369556), Washington, D.C. This presumably was one of the "37 specimens in the Duerden Collection" mentioned by Woodring,

The remaining 36, which can be considered paratypes, were not found in the paleontological collection from Johns Hopkins University on deposit at USNM (May, 1965). Twenty topotypes from the Henderson collection are at USNM (no. 135509).

Fossil record (see map, Pl. 53, black triangle)—JAMAICA: near Bowden, St. Thomas Parish (1894, J.B. Henderson, Jr.; 1899, J.E. Duerden; in thin bed imperfectly consolidated gravel in a marly matrix; USNM).

***Gabrielona sulcifera* Robertson, new species**

(Pls. 53-57)

Range—Recent: known only from off northwestern Cuba, Greater Antilles, from the Virgin Islands, and from Antigua, Lesser Antilles. Presumably widespread around high islands throughout the West Indies, but very rarely collected.

Chief distinguishing characters—This is the only species in the genus having a shell with prominent spiral sculpture. This begins on the second whorl as keels, which soon become cords. On later whorls the cords are reduced and broadened to interspaces between sulci. These sulci are absent at and near the periphery of the last whorl of large shells. Also differs from other Recent species in the genus as follows: very fine axial threads on second whorl; color pattern with



Plate 53. Geographical records of *Gabrielona sulcifera* Robertson (Recent) [round spots] and *Gabrielona hadra*

(Woodring), its Middle Miocene (or Plio-Pleistocene) precursor [triangle].

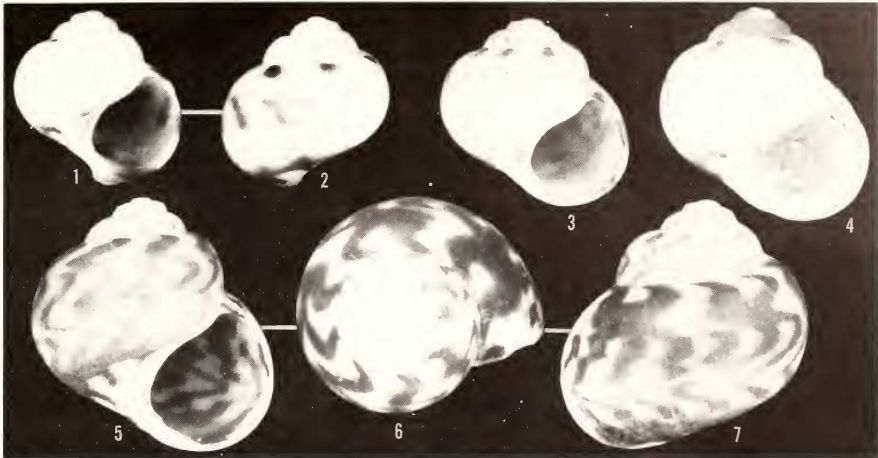


Plate 54. *Gabrielona sulcifera* Robertson. Antigua, Lesser Antilles. Fig. 4. Holotype. All $\times 20$.

no demarcated subsutural area; palatal sulcus near middle of aperture and not correlated with color pattern on external surface; palatal denticle can be present; only lower columellar denticle (cd_2) present (abnormally, slight trace upper columellar denticle); operculum with prominent spiral cord at inner edge marginal spiral ridge. For differences from *G. hadra*, see under that species.

Relationships—Judging by the presence and kind of sculpture (even though spiral and not axial), the fairly thick, generally similarly-shaped shells, and the two opercular resemblances, *G. sulcifera* seems more closely related to *G. ravanana* than to the other two Recent species. However, the differences are far greater than those between *G. nepeanensis* and *G. pisinna*.

Abundance—14 specimens available, only 1 live collected and with an operculum.

Habitat—The single live-collected specimen and 11 empty shells were all dredged together at an unrecorded depth at Antigua, and were in "deep, fine sand and shells." To have been in or near English Harbour, the depth must have been less than about 20 fathoms (H.O. chart 366). The empty, drilled, abnormal shell from 287 fathoms off northwestern Cuba probably was adventitious at that depth.

Shell description [see also section on abnormal shell]—Attains length of 2.4 mm., width

of 2.3 mm., and 4.3 whorls; spire angle 90° - 105° ; length exceeds width, and even small shells high-spined; outline fairly variable (Pl. 56, figs. 1-3); fairly thick and slightly translucent to slightly transparent. Protoconch slightly exsert, slightly inflated, smooth, white, fairly prominently demarcated from teleoconch by slight varix, 1.1-1.2 whorls. First whorl 0.25-0.26 mm. in diameter. Penultimate and last whorls: flattening below suture and slight shoulder (Pl. 56, figs. 1-3); commonly: slight spiral bulge around umbilical area (Pl. 56, figs. 4, 9). Sculpture of second whorl: 3 spiral keels on first quadrant following protoconch varix, the middle keel (on shoulder) the most prominent; keels less prominent on second to fourth quadrant, gradually becoming spiral cords, with one or two more cords intercalated; very fine axial threads (Pl. 56, fig. 5). On later whorls, cords are reduced and broadened to interspaces between spiral sulci; 8-12 sulci above suture on penultimate whorl. Last whorl of small shells: 25-28 spiral sulci between suture and base. Sulci absent at and near periphery of large shells, and wholly absent near outer lip where surface is smooth except for axial growth lines; sulci fairly regularly to irregularly spaced (fairly uncommonly, in closely-spaced pairs), especially variable below and near suture; termination of sulci commonly abrupt. Surface shiny. Colors: pale pinkish brown or orange-brown, and white. Patterns: no demarcated subsutural area; on middle whorls: irregular axial bars at shoulder (0-10 per whorl), and near and

above periphery (7-17 per whorl), developing into wavy bands; on last whorl large shells: axially aligned, broadly wavy brownish bands arising from suture and extending to base, 6-11 on last whorl, commonly coalesced into irregular spiral areas on shoulder and on base, and commonly disjunct subperipherally; umbilical area: white, with 5-9 (usually 6) axial or very steeply descending brownish bands extending from middle of base; fairly rarely: all brownish marks very pale and peripheral area uniformly whitish (Pl. 54, fig. 4). Aperture slightly more rounded than in other Recent species (less constricted near suture); outer lip and callus on upper parietal area fairly thick to thick; palatal denticle on most large shells, commonly wide and faint; apertural ridge (ar) shallow in aperture; palatal sulcus near middle of aperture (lacking in smallest shell); upper columellar denticle (cd_1) absent; lower columellar denticle (cd_2) present, commonly wide (Pl. 56, figs. 4, 9). Columellar lip not thickened, and steep slope into umbilical channel but no escarpment; escarpment to left of umbilical channel fairly prominent, arising fairly high to high off outer edge columellar lip; broad area to left of this escarpment, commonly with several parallel threads; umbilicus fairly wide to wide.



Plate 55. *Gabrielona sulcifera* Robertson. Off northwestern Cuba. Abnormal shell. All $\times 20$.

Abnormal shell (Pl. 55)—The single empty shell from 287 fathoms off northwestern Cuba (USNM no. 94974) differs strikingly from all those from Antigua, but seems to be conspecific. The protoconch and beginning of the second whorl are normal, but the surface is increasingly corroded as far as a growth line in the first quadrant of the third whorl. Thereafter, the external surface is smooth and shiny and lacks sulci. Another growth line is at the beginning of the second quadrant of the third whorl. I conclude from the growth-lines, which are much more clear-cut than on any other *Gabrielona* observed, that growth of this shell was abnormal, perhaps because the animal lived in an unusual habitat (depth?).

Other differences from the Antiguan specimens: spire lower (spire angle ca. 115°); width exceeds length (resembles *G. pisinna* in outline); thick; coloration dark brick red and white; dark areas large, with banding complex and greatly coalesced; apertural ridge (ar) fairly deep in aperture; slight trace upper columellar denticle (cd_1); shallow slope from columellar lip into wide umbilical channel; no trace escarpment to left.

Shell measurements (mm.)—

length	width	no. whorls	
2.42	2.27	4.3	largest (Antigua)
2.13	2.25	3.8	abnormal (N.W. Cuba)
1.98	1.93	4.0	average; holotype
1.33	1.17	3.5	smallest (St. Croix)

Operculum (Pl. 56, figs. 6-8)—The single operculum available is different from all other known *Gabrielona* opercula in having a prominent spiral cord at the inner edge of the marginal spiral ridge. The operculum of *G. sulcifera* is almost as thick as those of *G. raumana*, and the opercular whorl counts of these two species are also similar. In outline, the operculum of *G. sulcifera* is slightly more rounded than those of all the other Recent species—a consequence of the more rounded aperture. In the central region, a faint spiral ridge separates the smooth outer spiral area from the smooth central area. The callus is thin, revealing some of the spiral suture at the surface. The non-spiral columellar edge is steeply beveled. The spiral edge seems to be corroded at the external surface, and the sharp crest of the spiral ridge may therefore be an erosional feature.

Radula (Pl. 57; 1 studied)—Attains length of 0.7 mm., width of 0.13 mm., and with as many as 30

fairly strongly curved transverse rows of teeth (including a few nascent rows). Central monocuspid, with the small anterior portion of the base in a cleft between the bases of the innermost pair of laterals; the remainder of the base of the central overlapping these (where they are juxtaposed posteriorly). Five pairs of laterals, each of these (like the central) with a small distal portion that is monocuspid; the outer edge of each base partly overlaps the base lateral to it. As many as 34 pairs of marginals (lowest count 26), the innermost large and massive with lobed cusps, the distal portions gradually becoming smaller and more slender outwards, and with finer denticulations that finally are absent altogether on the outermost teeth.

Synonymy—

1889 *Phasianella (Eucosmia) brevis* "Orbigny" Dall [*Eucosmia brevis* in plate caption] (not *P. brevis* Orbigny, 1842). Bull. Mus. Comp. Zool. 18: 30 [listed], 351.

- pl. 19, fig. 10b [not North Carolinian specimens, which are *Tricolia thalassicola* Robertson (deep water form) and perhaps other species of *Tricolia*].
- 1918 *Eucosmia brevis* ("Orbigny") Cossmann (not *P. brevis* Orbigny). Essais Paleocouch. Comp., Paris, livr. 11, p. 162, fig. 55 [outline copied from Dall, 1889].
- 1958 *Gabrielona brevis* ("Orbigny") Robertson (not *P. brevis* Orbigny, 1842). Johnsonia 3 (37): 257-260, pl. 138, fig. 2 [radula], pl. 139, figs. 3-4 [operculum], pl. 140, figs. 2-3, pl. 141 [not pl. 142, fig. 1].

Types—The holotype (Pl. 54, fig. 4), the live-collected specimen from Antigua, is at the United States National Museum (no. 500636), Washington, D.C. Of the original 11 Antigua paratypes, 7 are still at USNM (no. 659066), 2 are at the Museum of Comparative Zoölogy (no. 188356), 1 is at the Academy of Natural Sciences of Philadelphia (no. 302625), and 1 (Pl. 54, fig. 3) was lost. The smallest paratype, from St. Croix, is in Mr. Ustick's private collection. The abnormal shell from Cuba is not a paratype.

Derivation of new name—Latin, *sulcifer*, bearing furrows.

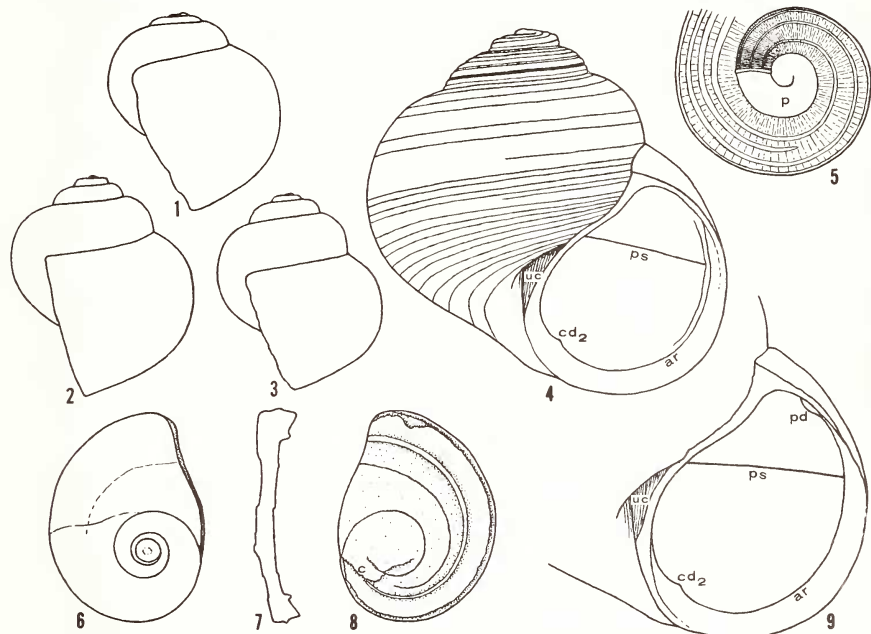


Plate 56. *Gabrielona sulcifera* Robertson. Figs. 1-3. Outlines of large shells, showing variation, all x17. Fig. 1. Abnormal shell from off northwestern Cuba. Fig. 3. Unusually high-spired shell. Fig. 4. Holotype, showing position of sulci, x33. Fig. 5. Apex, x60; p, protoconch. Figs. 6-8. Operculum of

holotype. Internal surface, longitudinal section, and external surface (respectively). All x33; e, lower edge of callus. Fig. 9. Aperture, x33; ar, apertural ridge; cd, lower (inner) columellar denticle; pd, palatal denticle; ps, palatal sulcus; uc, umbilical channel.

Nomenclature—Following Dall (1889), who first applied the name *Phasianella brevis* Orbigny, 1842, to the abnormal Cuban shell discussed and refigured here (Pl. 55), I misapplied this name to this species and transferred it to *Gabrielona*. Subsequent study of the holotype (figured specimen) of *P. brevis* at the British Museum (Nat. Hist.), no. 1854.10.4.282, has shown that this is a depauperate *Tricolia*. This holotype, inadequately illustrated in Robertson (1958, pl. 142, fig. 1), will be treated in detail and refigured elsewhere.

Locality records (see map, Pl. 53, circular black spots)—CUBA: off Bahía Honda, Pinar del Río (23°2'N.; 83°13'W.; 287 fms.; Blake Sta. 21 [1877-78]; USNM). VIRGIN ISLANDS: Christiansted Harbor, St. Croix (dredged 15 ft [1 dead]; G. N. Usticke). LESSER ANTILLES: English Harbour, Antigua (1918, J. B. Henderson, Jr., USNM, MCZ, ANSP).

Erroneous locality record—Arenas de la Chorrera, Habana, Cuba (Robertson, 1958, pp. 259-260, as *G. brevis*) [a juvenile *Tricolia*].

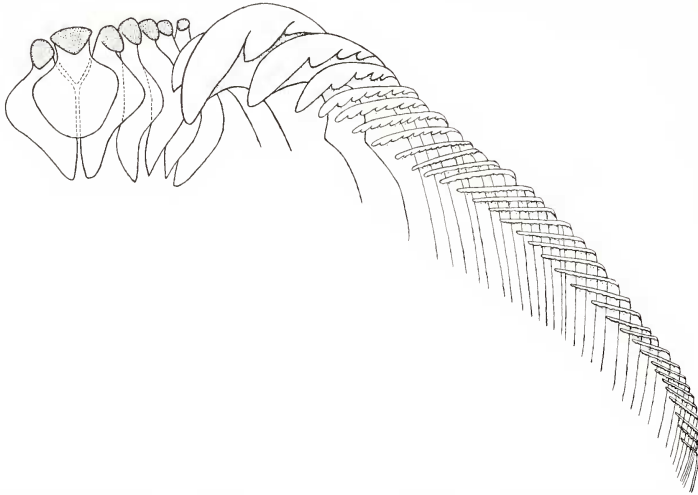


Plate 57. *Gabrielona sulcifera* Robertson. Half of one transverse row of radular teeth, showing (from left to right) the central between the innermost pair of laterals, the remaining four laterals on the right side, and the entire row of margin-

als. The cusps of the central and laterals are stippled. From the holotype, Antigua, West Indies. $\times 1500$. Modified from Robertson (1958, pl. 138, fig. 2, as *Gabrielona brevis*).

EXCLUDED SPECIES

"Gabrielona" bruscasensis Weisbord, 1962

(Pl. 58)

Range—Upper Miocene or Pliocene (or younger?): known only from one locality in the Playa Grande Formation (Maiqueña Member), northern Venezuela.

Remarks—This species was described from a single poorly preserved shell with a badly broken columellar area. Even generic identification has been a problem but the shell does seem to be a phasianellid. However, it cannot be a *Gabrielona* because the slight axial ridge revealing the position of the withdrawn operculum is detectable, and this is fairly deep in the aperture. I detected no palatal sulcus or apertural denticles, and the part remaining of the umbilical area indicates that there was no *Gabrielona*-like umbilical channel. The outer lip is more prosocline than in any true *Gabrielona*. I conclude that *G. bruscasensis* probably is a young *Tricolia*.

The specimen lacks most of the characters distinguishing species of *Tricolia*. The apex is in such poor condition that the whorls cannot be counted accurately and the first whorl cannot be measured. The shell is suffused with pale brownish pink, but no color pattern is detectable. Similar-sized shells of *T. affinis cruenta* Robertson differ in outline (are more elongate, with a more obtuse apex) and lack the umbilicus. *G. bruscasensis* is here considered a *nomen dubium*.

Synonymy—

1962 *Gabrielona bruscasensis* Weisbord, *Bull. American Paleol.*, 42(193): 111, pl. 8, figs. 5-7 (Quebrada las Bruscas [Playa Grande Formation], Distrito Federal, Venezuela).

Type—The holotype is at the Paleontological Research Institution (no. 26056), Ithaca, New York.

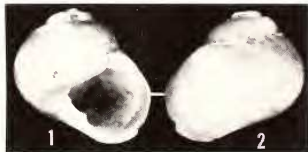


Plate 58. *"Gabrielona" bruscasensis* Weisbord, probably a young *Tricolia*. Upper Miocene or Pliocene [?], northern Venezuela. Holotype. Both $\times 20$.

"Gabrielona" sphaera Weisbord, 1962

(Pl. 59)

Range—Pliocene (or younger?): known only from three nearby localities in the Mare Formation, northern Venezuela.

Remarks—This is a rissoscean. Although resembling in outline a high-spined *Gabrielona*, it cannot be one because the shell (for its size) is thin, the periphery of the last whorl is lower than in any known *Gabrielona*, the aperture is elongate-ovate, there are no apertural denticles, and neither is there a palatal sulcus. There is a wide umbilicus and a broad umbilical channel that is slightly angled at its lower left margin. The holotype has 3.4 whorls and the first whorl is 0.23 mm. in diameter. The callus on the upper parietal area is incomplete medially. In coloration, the shell is pale (faded?) amber and whitish near the umbilicus and on the last part of the last whorl where there are irregular amber markings. At the apex, the beginning of the suture is tinged with dark amber.

Synonymy—

1962 *Gabrielona sphaera* Weisbord, *Bull. American Paleol.*, 42(193): 109-111, pl. 8, figs. 1-4 (near Quebrada Mare Abajo [Mare Formation], Distrito Federal, Venezuela).

Types—The holotype is at the Paleontological Research Institution (no. 26054), Ithaca, New York. So also is the single paratype (no. 26055) distinguished by Weisbord among eleven other specimens identified with *G. sphaera*.



Plate 59. *"Gabrielona" sphaera* Weisbord, a rissoscean. Pliocene [?], northern Venezuela. Holotype. Both $\times 20$.